International Year of Light Blog

James Clerk Maxwell, the man who changed the world forever I

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On June 13, but in 1831 the Scottish physicist James Clerk Maxwell (http://light2015blog.org/2015/03/18/james-clerk-maxwell-man-of-light/) was born. In 1865, one hundred and fifty years ago, he published an article titled *A Dynamical Theory of the Electromagnetic Field* (http://rstl.royalsocietypublishing.org/content/155/459.full.pdf), which not only included the electromagnetic field equations (today known as «Maxwell's equations»), but also predicted the existence of electromagnetic waves moving at the speed of light, and presented the electromagnetic theory of light. In this article he stated: «it seems we have strong reason to conclude that light itself (including radiant heat, and other radiations if any) is an electromagnetic disturbance in the form of waves propagated through the electromagnetic field according to electromagnetic laws». He was not wrong. Then, in 2015, we celebrate the 150th anniversary of the electromagnetic theory of light, which is one of the milestones commemorated in the International Year of Light and Light-Based Technologies (IYL 2015).

(https://light2015blogdotorg.files.wordpress.com/2015/06/figure_1.jpg)
Statute James Clerk Maxwell with his dog Toby at his feet and holding his colour wheel, Edinburgh (Scotland). Credit: A. Beléndez.

James Clerk Maxwell

Maxwell (1831-1879) is considered as one of the most important scientists of all time and one of the greats in the history of physics, along with Newton and Einstein. Undoubtedly, his more important scientific contribution is the theory of the electromagnetic field, fundamental not only for the comprehension of natural phenomena, but also for its technical application, in particular in the today ever-present field of telecommunications. He was born in Edinburgh, Scotland, on 13 June 1831 to a well-established family. Two years later, the family moved to a small country estate in Middlebie, Galloway, about 90 miles southwest of Edinburgh. His father had been inherited his estate and there he enthusiastically began to supervise the construction of a new house, which he called "Glenlair." In Glenlair James Clerk Maxwell not only spent long periods of times but also he wrote some of his more important scientific contributions. After receiving private education in Glenlair, James was sent to Edinburgh Academy, where he spent five years. In 1847 he enrolled at Edinburgh University and, three years later, he went up to the University of Cambridge, the most influential centre of physics at the time, where he graduated as Second Wrangler in the Mathematical Tripos of 1854 and he won the Smith Prize the same year. In the Smith's Prize examination, question 8 was on Stokes' Theorem. Some years later Maxwell would use this theorem in his work on the electromagnetic field.

In 1856, Maxwell got the Chair of Natural Philosophy at Marischal College, one of the two universities in Aberdeen at that time, where he spent four years. There he began his researches on colour theory and married Katherine Mary Dewar, daughter of the College Principal. Perhaps is less known that Maxwell was awarded the Adams Prize with an essay titled *On the stability of the motion of Saturn's rings* (https://archive.org/details/onstabilityofmot00maxw) which was published in 1859 and where he concluded that «the only system of rings which can exist is one composed of an indefinite number of unconnected particles, revolving around the planet with different velocities according to their respective distances.» Maxwell's work about the Saturn's rings was defined by George Airy (http://en.wikipedia.org/wiki/George_Biddell_Airy), the Astronomer Royal, as «one of the most remarkable applications of mathematics to physics that I have ever seen.» In 1895, sixteen years after Maxwell's death, the spectroscopic study made by the American astronomer James Keeler (http://en.wikipedia.org/wiki/James_Edward_Keeler) confirmed the theory of Maxwell that Saturn's rings are made up of countless small objects.

(https://light2015blogdotorg.files.wordpress.com/2015/06/figure_2.jpg)
A young James Clerk Maxwell holding his colour wheel (Trinity College Library, Cambridge University). Credit: AIP Emilio Segre Visual Archives.

In 1860, he left Aberdeen to occupy another professorship in King's College, London. The five years Maxwell spent in London were probably the most creative in his life: colour vision and gas kinetic theories as well as the dynamical theory of the electromagnetic field. There he also produced the world's first colour photography (http://light2015blog.org/2015/03/18/james-clerk-maxwell-man-of-light/), which was projected onto a screen at the Royal Institution in May of 1861. Maxwell was elected to the Royal Society three weeks later.

Maxwell is also one of the founders of statistical physics. In 1860 he published *Illustrations of the dynamical theory of gases* in which he needed only one page to obtain the law of distribution of molecular velocities, known today as Maxwell's distribution of molecular velocities. Maxwell was the first to formulate a statistical law that governs a physical phenomenon. Again, and as happened with his hypothesis of Saturn's rings, this law also was proven experimentally in this case by the German physicist Otto Stern (http://en.wikipedia.org/wiki/Otto_Stern) in 1920 using the molecular ray method.

Maxwell resigned his King's professorship voluntarily in 1865, mid session, and went back to his Scottish estate in Glenlair. He wrote his *magnus opus* there, *A Treatise on Electricity and Magnetism*, published in 1873, two volumes of more than 500 pages each, peak of nineteenth century physics and comparable to Newton's *Principia*, published almost two centuries before. In his *Treatise* Maxwell manages to unify all known phenomena at the moment regarding electricity and magnetism.

In 1871, Maxwell was appointed to take up the newly created Professorship of Experimental

Physics at the University of Cambridge, and he became the first director of a new research centre, the Cavendish Laboratory, and became the first Cavendish Professor of Physics. Other directors who succeeded him were Lord Rayleigh, J. J. Thomson and Rutherford. To date 29 Nobel Prize winners have worked in the Cavendish Laboratory. Maxwell supervised every detail of the construction of the Laboratory. However, in 1877 Maxwell's health started to fail. He passed away due to an abdominal cancer on 5 November 1879. He was 48.

MORE INFORMATION:

Augusto Beléndez, "Electromagnetic Unification: 150th Anniversary of Maxwell's Equations", Mètode Nº 84, Winter 2014/15. (http://metode.cat/en/Issues/Article/La-unificacio-electromagnetica)

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2. Campbell and W. Garnett, The life of James Clerk Maxwell (MacMillan and co., Londres 1882). (http://ir.nmu.org.ua/bitstream/handle/123456789/144168/b417ada143d3d930e27ad532eb61880f.pdf?sequence=1)
3. Forbes and B. Mahon, Faraday, Maxwell, and the Electromagnetic Field: How two men revolutionized Physics (Prometheus Books, New York 2014). (http://www.prometheusbooks.com/index.php?main_page=product_info&products_id=2207&zenid=jtcf8i7b3lqbqdcj2rp46i2df7)
4. Flood, M. McCartney and A. Whitaker (eds.), James Clerk Maxwell. Perspectives on his Life and Work (Oxford University Press, Oxford 2014). (http://ukcatalogue.oup.com/product/9780199664375.do)

(https://light2015blogdotorg.files.wordpress.com/2015/06/figure_5.jpg)Augusto Beléndez (@aubeva (https://twitter.com/aubeva)) is Full Professor of Applied Physics, leader of the Group of Holography and Optical Processing and Director of the University Institute of Physics Applied to Sciences and Technologies at the University of Alicante of Spain. He is mainly interested in holography, holographic recording materials, holographic optical elements, optical storage, and the teaching of physics and engineering. He is a member of the

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He is active in public outreach: he has published numerous articles in popular science journals, and in the media. In 2009 he started the blog "Física para tod@s (http://blogs.ua.es/fisicateleco)", and he has given some talks to general public on science.

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